CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-122

June 12, 1981

1. Name of fault:

Calaveras, Coyote Creek, Animas, San Felipe, and Silver Creek faults.

2. Location of fault:

Morgan Hill and Mt. Sizer 7.5-minute quadrangles, Santa Clara County (figure 1).

3. Reason for evaluation:

Part of 10-year fault evaluation program (Hart, 1980).

4. List of references:

Armstrong, C.F., 1979, Coyote Lake earthquake, 6 August 1979: California Geology, v. 32, no. 11, p. 248-251.

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Bryant, W.A., 1981b, Calaveras fault zone, Mission fault, and San Felipe fault, Alameda and Santa Clara Counties: California Division of Mines and Geology Fault Evaluation Report FER-115 (unpublished).

California Division of Mines and Geology, 1974, Official Map of Special Studies Zones, Morgan Hill quadrangle.

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Cotton, W.R., 1972, Preliminary geologic map of the Franciscan rocks in the central part of the Diablo Range, Santa Clara and Alameda Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-343.

Dibblee, T.W. Jr., 1973a, Preliminary geologic map of the Morgan Hill quadrangle, Santa Clara County, California: U.S. Geological Survey Open File Map.

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Earth Sciences Associates, 1981, Lineations associated with surface expression of Calaveras fault between Sunol Valley and Hollister, California: Unpublished consulting map for Pacific Gas and Electric.

Frames, D.W., 1955, Stratigraphy and structure of the lower Coyote Creek Area, Santa Clara County, California: unpublished M.S. Thesis, University of California, Berkeley.

Hart, E.W., Bryant, W.A., and Bedrossian, T.L., 1979, Observations of fault rupture associated with the August 6, 1979 earthquake and tabulation of observed data: California Division of Mines and Geology, in-house memo of August 16, 1979 to C.F. Armstrong, 6p., map scale 1:24,000.

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Nilsen, T.H., 1972, Preliminary photointerpretation map of landslides and other surficial deposits of parts of the Los Gatos, Morgan Hill, Gilroy Hot Springs, Pacheo Pass, Quien Sabe, and Hollister 15-minute quadrangles, Santa Clara County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-416 (also Basic Data Contribution 46), map scale 1:62,500.

Pampeyan, E.H., 1979, Preliminary map showing recency of faulting in coastal north-central California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1070.

Radbruch, D.H., 1968, Map showing recently active breaks along the Hayward fault zone and the southern part of the Calaveras fault zone, California: U.S. Geological Survey Open File Map.

Radbruch-Hall, D.H., 1974, Map showing recently active breaks along the Hayward fault zone and the southern part of the Calaveras fault zone, California: U.S. Geological Survey Miscellaneous Investigations Map I-813.

U.S. Soil Conservation Service, 1939, Black and white aerial photographs, CIV series, flight 284, numbers 89-91; flight 294, numbers 40-56, and 85-104; and, flight 299, numbers 18-27; scale approximately 1:20,000.

U.S. Department of Agriculture, 1950, Black and white aerial photographs, CIV series, flight 12G, numbers 75 to 78; scale approximately 1:20,000.

U.S. Geological Survey, 1974, Color aerial photographs, low sun, photos 9-193 to 9-208.

Wagner, D.L., 1978, Environmental geologic analysis of the Diablo Range Study Area II, southern Santa Clara County, California: California Division of Mines and Geology Open File Report OFR 78-12SF.

Williams, J.W., Armstrong, C.F., Hart, E.W., and Rogers, T.H., 1973, Environmental geological analysis of the South County Study Area, Santa Clara County, California: California Division of Mines and Geology Preliminary Report 18.

Woodward-Lundgren and Associates, c1973, Supplementary geologic investigation, Rancho San Jose, San Jose, California: Unpublished consulting report for Oceanic California, Inc. (C-52).

5. Review of available data and air photo interpretation:

Calaveras Fault

The Calaveras fault evaluated in this Fault Evaluation Report (FER) is a complex zone of right-lateral strike-slip faulting (figure 1). Land surfaces along the Calaveras fault have not been extensively modified by man. However, massive landsliding and lateral spreading obscure fault traces in the Anderson Lake and Coyote Creek areas (figures 3a, 3b).

The FER study area is located within the Morgan Hill and Mt. Sizer 7.5-minute quadrangles. The Calaveras fault depicted on the 1974 Special Studies Zones (SSZ) Map of the Morgan Hill quadrangle is based on mapping by Dibblee (1973a), Radbruch (1968), and Cotton (1972) (figure 3a). A more recently released map by Radbruch-Hall (1974) is essentially the same as the 1968 map. The Calaveras fault depicted on the 1974 SSZ Map of the Mt. Sizer quadrangle is based on mapping by Dibblee (1973b), Radbruch (1968), and Williams and others (1973) (figure 3b).

The main traces of the Calaveras fault are generally well-defined in the Morgan Hill quadrangle, based on recent, fault produced geomorphic features, especially in the northern part of the quadrangle (figure 4a). These fault traces are very similar to traces mapped by Dibblee (1973a) and Cotton (1972) north of locality 1, and to most traces mapped by Radbruch-Hall (1974) south of locality 1. A complex zone of recent faulting characterizes the Calaveras fault from locality 1 southeastward through the remainder of the FER study area (figure 3a, 3b). Southeast of locality 1 fault traces mapped by Radbruch (1968), Dibblee (1973a), and Cotton (1972) agree in general with air photo interpretation of the Calaveras fault by this writer, but differences in location and recency of activity exist (figures 3a, 4a).

The east branch Calaveras fault of Cotton (1972) was zoned because Cotton mapped the fault as "active." However, no specific data was presented supporting the activity of the east branch Calaveras fault. Geomorphic evidence of Holocene-active faulting was not observed along the east branch Calaveras fault, based on air photo interpretation by this writer (figure 3a). Dibblee (1973a) and Radbruch-Hall (1974) did not verify these traces of Cotton. Holocene alluvial deposits about 2500 feet north of locality 1 are not offset by this fault (Dibblee, 1973a) (figure 3a).

The Calaveras fault in the Mt. Sizer quadrangle branches into several complex traces near the southern boundary of T8S, and is partly obscured by massive landlsiding in the vicinity of locality 2 (figure 4b). Mapping by Radbruch-Hall (1974) is in general agreement with air photo interpretation by this writer, although differences in detail exist (figures 3b, 4b).

Williams and others (1973) mapped a segment of the Calaveras fault for about 7,000 feet in the southern part of the Mt. Sizer quadrangle (figure 3b). The eastern trace of Williams and others coincides with the fault trace of Radbruch-Hall (1974) (figure 3b). Williams and others' west trace is shown as inferred on the 1974 SSZ Map and is generally located within massive landslide deposits. No geomorphic evidence of recent faulting was observed along Williams and others' west trace Calaveras fault, based on air photo interpretation by this writer (figures 3b, 4b).

Wagner (1978) mapped a segment of the Calaveras fault near locality 2 southeast to the NE 1/4 section 19, T9S, R4E. Wagner's fault traces do not differ significantly with traces of Dibblee (1973b) and Radbruch-Hall (1974), although differences exist in the massive landslide area near locality 2. Only those traces of Wagner that differ from those of Radbruch-Hall and Dibblee are shown on figures 3b and 4b.

Historic fault creep has offset the Cochrane Bridge at the southeastern end of Anderson Lake (Radbruch-Hall, 1974) (figure 3b). Surface fault rupture associated with the 6 August 1979 Coyote Lake earthquake (M 5.9) occurred across East Dunne Road (figure 3b). Left-stepping en echelon cracks trending N 30° W had an observed right-lateral strike-slip displacement of 5 to 10 mm (Hart, 1979). This crack zone occurred along the east margin of an active landslide.

San Felipe Fault

The San Felipe fault depicted on the 1974 SSZ Map of the Morgan Hill quadrangle is based on mapping by Dibblee (1973a) and Cotton (1972) (figure 3a). The San Felipe fault was zoned for special studies based on an inferred offset of older alluvium (Pleistocene) mapped by Dibblee (1972) in San Felipe Valley (Lick Observatory quadrangle), located about 1 mile northwest of the Morgan Hill quadrangle boundary (figure 3a). Also, Cotton (1972) indicated on his map that the San Felipe fault was active.

Bryant (1981b) did not find evidence indicating offset older alluvium in the Lick Observatory quadrangle where Dibblee (1972) maps an inferred fault. Older alluvium of Pleistocene age is not offset by the San Felipe fault at locality 3 (figure 3a) (Dibblee, 1973a). Air photo interpretation by this writer indicates that erosional features characteristic of bedrock faulting are located along Dibblee's and Cotton's traces of the San Felipe fault, but geomorphic evidence of Holocene-active faulting was not observed. The San Felipe fault is not well-defined except in the area just north of locality 3 (figure 3a).

Animas Fault

The Animas fault depicted on the 1974 SSZ Map of the Morgan Hill quadrangle is based on mapping by Dibblee (1973a) (figure 3a). Dibblee maps this fault as a reverse fault, north side up. The Animas fault was originally zoned based on the offset of Plio-Pleistocene Santa Clara Formation against Mesozoic sedimentary rocks.

Dibblee (1973a) does not map the Animas fault at locality 4 (incorrectly shown as inferred and concealed on the 1974 SSZ Map of the Morgan Hill quadrangle) (figure 3a). Instead, Dibblee maps an outcrop of queried Santa Clara Formation (or possible Pleistocene older alluvium) in contact with Cretaceous bedrock.

No geomorphic evidence of Holocene faulting was observed by this writer, based on interpretation of 1939 USSCS and 1972 USGS air photos (figure 3a). No Holocene alluvial deposit is offset and drainages that cross the fault are not offset.

Silver Creek Fault

The Silver Creek fault depicted on the 1974 SSZ Map of the Morgan Hill quadrangle is based on mapping by Dibblee (1973a) (figure 3a). The Silver Creek fault was zoned based on the offset of Plio-Pleistocene San Clara Formation against serpentine of Mesozoic age. Dibblee maps the Silver Creek fault as a steeply dipping reverse fault with serpentine on the west faulted against Plio-Pleistocene Santa Clara Formation on the east. The dip of the fault is generally southwest, but Dibblee indicates a 60° NE dip just north of Melcalf Road.

The Silver Creek fault is generally well-defined along most of its trace because of the strong lithologic contrast between weak beds of the Santa Clara Formation and relatively resistant serpentine. Geomorphic features indicating Holocene-active faulting genrally were not observed along the trace of the Silver

Creek fault, based on air photo interpretation by this writer (figure 3a). Systematic offset of ridges or knickpoints in drainages resulting from vertical offset were not observed. Thus, the well-defined segments of the fault are probably the result of differential erosion rather than Holocene faulting.

The oldest unfaulted geologic unit across the Silver Creek fault is a late Pleistocene older alluvial unit mapped by Dibblee about 3,000 feet north of Pigeon Point at locality 5 (figure 3a). This indicates that movement along this segment of the Silver Creek fault has not occurred since late Pleistocene time.

About 3,000 feet southeast of locality 5 geomorphic features indicating Holocene activity coincide with the trace of the Silver Creek fault (locality 6, figure 3a). A sense of systematic offset was not apparent and it is perhaps significant that these features were observed only in association with very recent, massive landsliding along the east-facing slope of the ridge west of Anderson Lake. A closed depression, sidehill trough, and benches at locality 6 are located just above the most recent landslides and may be within remnants of a larger, older landslide that had stabilized in the past. As the more recent landslides formed, the oversteepened head scarp area removed lateral support near the ridge crest area, creating an unstable condition. Lateral spreading near the ridge top in locality 6 probably occurred as a local response to shaking during strong to moderate earthquakes along the Calaveras fault. Northwest and southeast of locality 6 similar geomorphic evidence of Holocene activity was not observed.

Wagner (1978) indicates that a concealed trace of the Silver Creek fault is located beneath Anderson Reservoir (figure 3b). However, no fault-related geomorphic features were observed along Wagner's trace of the Silver Creek fault within Anderson Lake, based on interpretaion by this writer of pre-reservoir air photos (U.S.S.C.S., 1939).

Northwest of the FER study area the Silver Creek fault was evaluated by Bryant (FER-106, 1981a). Evidence of Holocene-active faulting was not observed and a recommendation to delete the SSZ was made.

Coyote Creek Fault

The Coyote Creek fault depicted on the 1974 SSZ Maps of the Morgan Hill and Mt. Sizer quadrangles was based on mapping by Dibblee (1973a, 1973b) (figures 3a, 3b). The decision to zone the Coyote Creek fault was based primarily on the offset of Plio-Pleistocene Santa Clara Formation, although a short segment of the Coyote Creek fault mapped by Dibblee (1973b) offsets Holocene alluvium (figure 3b) (see below).

The Coyote Creek fault is a moderately to steeply dipping reverse fault that offsets Mesozoic serpentine on the east over Plio-Pleistocene Santa Clara Formation (Dibblee, 1973a, 1973b). The fault is locally well-defined (see locality 7, figure 3a), but southwest-facing scarps near locality 7 are the result of differential erosion between resistant to very resistant serpentine and relatively weak Santa Clara Formation. A late Pleistocene terrace deposit (Helley and Brabb, 1971) 2000 feet east of the Wm. F. James Boys Ranch is not offset by the Coyote Creek fault. No drainages crossing the Coyote Creek fault are offset, indicating that the fault has not had surface rupture during Holocene time (figures 3a, 3b).

Dibblee (1973b) maps Holocene alluvium offset by the Coyote Creek fault at locality 8 (figure 3b). The graben-like area at locality 8 indicates extensional rather than compressional offset. Hill "971" to the west of the fault is about 150 to 170 feet higher than the area just east of the fault, which is opposite from what one would expect from the Coyote Creek fault plane geometry and sense of offset observed elsewhere along the fault trend. The geomorphic feature at this location is Holocene because of the ponding of alluvium and the closed depression. However, geomorphic features indicating reverse faulting during Holocene time are not present along the trend of the fault to the southeast. A WNW-trending ridge located 2500 feet south of locality 8 is crossed by the Coyote Creek fault. The ridge is continuous and is not offset in a vertical sense (figure 3b). Just northwest of the ponded alluvial area the Coyote Creek fault is located in a broad saddle. Farther northwest the fault is concealed by landslides, and evidence of recent faulting is not evident in the stream channel where the dam is presently located, based on interpretation of pre-reservoir air photos (USSCS, 1939).

Massive landsliding occurs along both the east and west-facing slopes of the rdige west of Anderson Lake, although landsliding on the east-facing slope is more predominant. It is probable that the broad trough, ponded alluvium, and closed depression are the result of massive landsliding or lateral spreading rather than Holocene-active faulting because: 1) the lowered east side along the fault trace is consistent with downhill movement and opposite to the sense of offset observed elsewhere along the Coyote Creek fault; 2) ponded alluvium and a closed depression in the trough indicate that extension has occurred, which is consistent with offset occurring at the head of landslides; 3) the spatial association of these geomorphic features with active, massive landsliding indicates compatibility with downslope movement rather than active faulting.

The east branch Coyote Creek fault mapped by Dibblee (1973b) offsets Santa Clara Formation (figure 3b). No geologic evidence of Holocene-active faulting was observed along the trace of this fault, based on air photo interpretation by this writer (figure 3b).

Three sub-parallel branches of the Coyote Creek fault are mapped by Wagner south of locality 8 (figure 3b). These faults are characterized by a series of aligned saddles and notches in Santa Clara Formation, but systematically offset drainages or scarps indicating Holocene-active faulting were not observed. Wagner (1978) concludes that the Coyote Creek fault "... probably has been inactive since early Pleistocene time."

6. Conclusions

Calaveras Fault

The main traces of the Calaveras fault are well-defined in most of the FER study area and are characterized by geomorphic features mandatory of Holocene-active faulting, such as systematic right-lateral offset drainages, closed depressions, sidehill benches, and linear troughs (figures 4a, 4b). Cochrane Bridge is offset right-laterally by ongoing fault creep (Radbruch-Hall, 1974). Surface fault rupture associated with the 6 August 1979 Coyote Lake earthquake offset right-laterally a segment of East Dunne Road about 5 to 10mm (Hart, 1979) (figure 3a, 4a).

Traces of the east branch Calaveras fault of Cotton (1972) are not well-defined and Holocene deposits are not offset along the fault. No geomorphic evidence of Holocene-active faulting was observed along the east branch Calaveras fault.

Selected fault traces of Dibblee (1973a), Radbruch-Hall (1974), Wagner (1978), and Bryant (this report) shown on figures 4a and 4b adequately delineate Holocene-active traces of the Calaveras fault.

San Felipe Fault

The San Felipe fault mapped by Dibblee (1973a) and Cotton (1972) does not offset Pleistocene deposits at locality 3 (Dibblee, 1973a) (figure 3a). Geomorphic features indicating Holocene fault activity were not observed along the San Felipe fault. This fault is generally not well-defined.

Animas Fault

The Animas fault of Dibblee (1973a) offsets Plio-Pleistocene Santa Clara Formation. Pleistocene older alluvial deposits at locality 4 are not offset by the Animas fault. Geomorphic evidence of Holocene-active faulting was not observed along the trace of this fault. This fault is not well-defined.

Silver Creek Fault

The Silver Creek fault mapped by Dibblee (1973a) offsets Mesozoic serpentine over Plio-Pleistocene Santa Clara Formation. Pleistocene older alluvial deposits at locality 5 (figure 3a) are not offset by the Silver Creek fault (Dibblee, 1973a). The strong lithologic contrast between resistant serpentine and relatively weak Santa Clara Formation results in locally well-defined, linear features. Geomorphic evidence of recent, systematic offset was generally not observed. However, at locality 6, Holocene-age geomorphic features coincide with the mapped trace of the Silver Creek fault. No sense of systematic offset was observed, and these recent geomorphic features are associated with massive landsliding and cannot be trace~~s~~d beyond the area of slope instability. It is concluded that the features at locality 6 are formed by lateral spreading rather than active faulting.

Wagner (1978) maps a concealed trace of the Silver Creek fault beneath Anderson Lake. No gemorphic evidence of Holocene-active faulting was observed along this projected fault trace, based on interpretation of pre-reservoir air photos (USSCS, 1939).

Coyote Creek Fault

The Coyote Creek fault mapped by Dibblee (1973a, 1973b) and Wagner (1978) offsets Plio-Pleistocene Santa Clara Formation. The Coyote Creek fault is locally well-defined, but fault scarps and aligned saddles are the result of differential erosion rather than Holocene-active faulting. No geomorphic evidence of Holocene-active faulting was observed along traces of the Coyote Creek fault. Holocene alluvial deposits, with the exception of locality 8 (figure 3b), are not offset along the Coyote Creek fault. A late-Pleistocene terrace deposit (Helley and Brabb, 1971) 2000 feet east of the Wm. F. James Boys Ranch is not offset by the Coyote Creek fault (figure 3a).

At locality 8, ponded alluvium and a closed depression within a broad trough indicate Holocene-activity coincident with Dibblee's (1973b) and Wagner's (1978) trace of the Coyote Creek fault (figure 3b). However, offset is consistent with extension rather than compression and the sense of offset is opposite (east side down) to that observed elsewhere along the Coyote Creek fault (east side up). The extensional sense of offset at locality 8 is associated with massive, active landsliding along both the east and west-facing slopes on the ridge west of Anderson Lake. Geomorphic features indicating Holocene-active faulting cannot be found northwest and southeast of locality 8. Due to the extensional sense of offset at locality 8, the association with massive, active landsliding, and the lack of evidence of Holocene-active faulting along the Coyote Creek fault to the northwest and southeast, it is concluded that these features are formed by down slope movement (lateral spreading) rather than surface fault rupture.

7. Recommendations

Recommendations for zoning faults for special studies are based on the criteria of sufficiently active and well-defined (Hart, 1980).

Calaveras Fault

Zone for special studies well-defined traces of the Calaveras fault mapped on the Morgan Hill quadrangles by Dibblee (1973a), Radbruch-Hall (1974), and Bryant (this report) as shown on figure 4a; and well-defined traces mapped on the Mt. Sizer quadrangle by Radbruch-Hall (1974), Wagner (1978), and Bryant (this report) as shown on figure 4b. Delete the east branch fault of Cotton (1972). This fault is not sufficiently active or well-defined.

San Felipe Fault

Delete traces of the San Felipe fault shown on the 1974 SSZ Map of the Morgan Hill quadrangle mapped by Dibblee (1973a) and Cotton (1972). This fault is not sufficiently active and generally is not well-defined.

Animas Fault

Delete the trace of the Animas fault shown on the 1974 SSZ Map of the Morgan Hill quadrangle mapped by Dibblee (1973a). This fault is not sufficiently active or well-defined.

Silver Creek Fault

Delete the trace of the Silver Creek fault shown on the 1974 SSZ Map of the Morgan Hill quadrangle. This fault is not sufficiently active and generally is not well-defined.

Coyote Creek Fault

Delete the trace of the Coyote Creek fault shown on the 1974 SSZ Maps of the Morgan Hill and Mt. Sizer quadrangles. This fault is not sufficiently active.

8. Report prepared by William A. Bryant, June 12, 1981.

William A. Bryant

WILLIAM A. BRYANT

WAB/map

I agree with recommendations
EWH
July 20, 1981

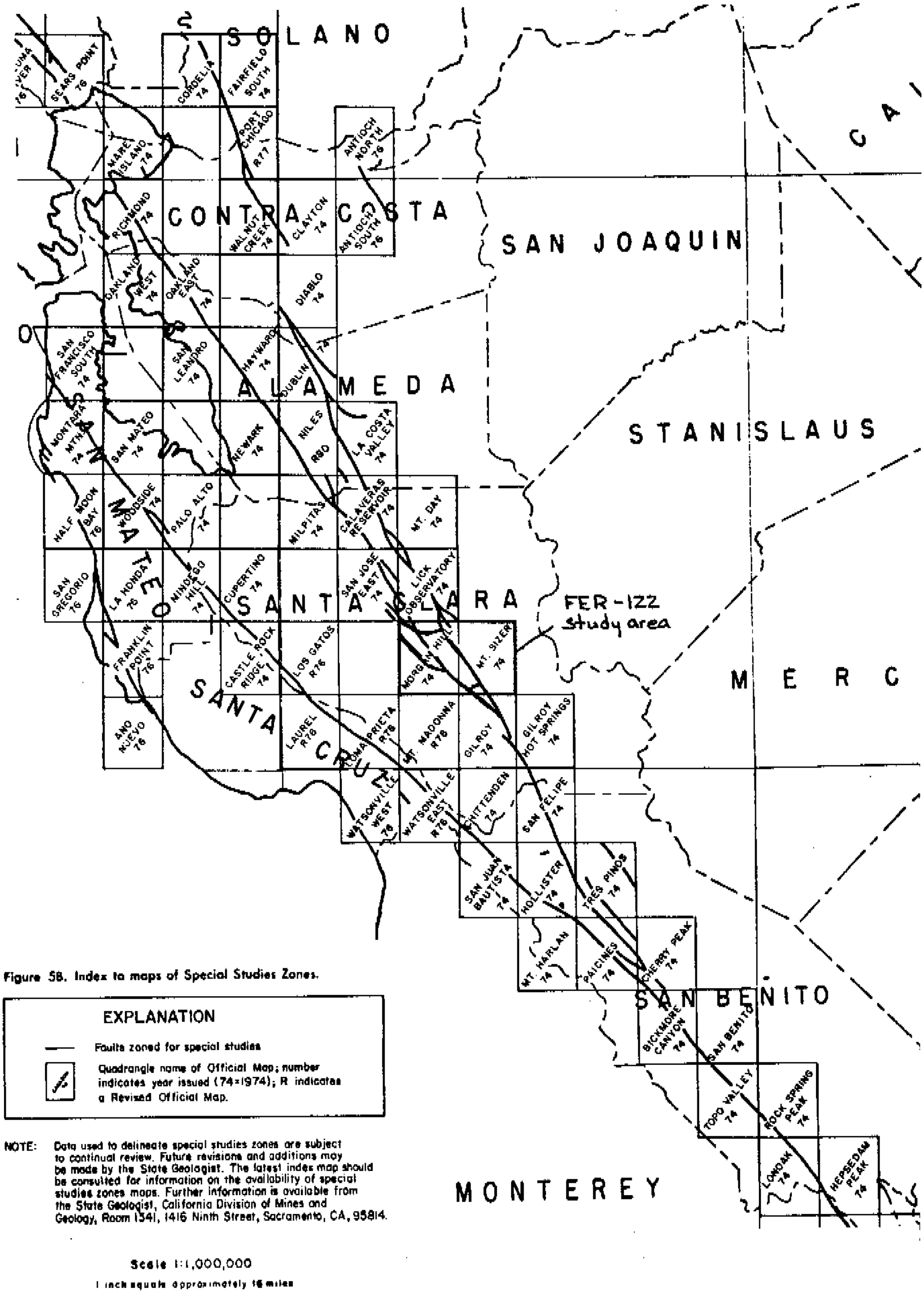

Figure 1 (to FER-122). Location of Calaveras fault zone to be evaluated in FER-122. Map from Hart, 1980.